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BRUCE GS 'B' DUMP SITE STUDY
1982 RESULTS AND
SUMMARY REPORT FOR 1977-1985

Report No 87-174-K

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ABSTRACT

Four pre-dump (1977-79) and one post-dump (1982) surveys were conducted to evaluate the effects of dumping of dredged material at the Bruce GS'B' disposal site in Lake Huron. Biological surveys were conducted approximately 490 m south of the disposal site. Changes in water quality between pre- and post-dump surveys were within normal seasonal and yearly fluctuations. Fine substrate analysis was attempted during each sampling period, but was only partially successful due to the heterogeneous nature of the substrate. Diver observations and photographs of the substrate revealed sharp angled rock fragments, indicative of recent deposition, at one of two locations. Side scan sonar survey results indicated the biological sampling site was in the vicinity of possible dumped material. Sedimentation rates were generally consistent between 1978 and 1982. The density of zoobenthic organisms was low both before and after dumping, consisting of mainly Oligochaeta and Diptera taxa. Alewife was the major fish species collected in gill nets during the three spring sampling periods. Burbot, collected in low numbers during all sampling periods, were most abundant after dumping. Yellow perch and longnose sucker were the most abundant species collected during fall sampling.

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EXECUTIVE SUMMARY

BRUCE GS 'B' DUMP SITE STUDY 1982 RESULTS AND SUMMARY REPORT FOR 1977-1985

L.P. King
R.W. Sheehan

The Ontario Ministry of Natural Resources requested Ontario Hydro to monitor the fish community response to the deposition of excavation material at the Bruce GS 'B' disposal site as a condition for disposal approval. To satisfy this request Biological Research Section commenced dump site studies in the fall of 1977 approximately 490 m (1600 ft) south of the actual disposal area. Four pre-dump (fall and spring 1977-79) and four post-dump surveys (fall and spring 1981-83) were planned. Water quality, sedimentation, substrate composition, and benthos and fish communities at the biological sampling area and at a control site 2 km south of the biological sampling area were to be monitored during the surveys. Control site surveys were discontinued after the completion of two surveys due to major differences in substrate composition between the control and biological sampling areas. After the initial post-dump survey (1982), the remaining post-dump surveys were deleted and replaced with diver substrate observations at selected underwater locations (1982), a required sounding survey (1984) and a side scan sonar survey (1985).

Water quality in the vicinity of the dump site before and after dumping of the excavated material was typical of Lake Huron. The concentrations of most water quality parameters varied slightly between each sampling year. Differences in pH and turbidity levels between pre- and post-dump surveys were within the normal seasonal and yearly fluctuations.

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Attempts were made to collect fine substrate components during each survey. However, the heterogeneous nature of the substrate and the type of sampling apparatus reduced sampling success. Considerable variation was evident in the pre-dump substrate composition near the dump site. Similar variation was evident in the 1982 post-dump substrate composition. Therefore changes in substrate composition are likely not due to the disposal of excavation material.

Analysis of substrate slides taken by divers at two dump site sampling locations indicated a heterogeneous substrate composed of boulder, cobble, pebble and clay, silt and sand fractions. A small number of sharp angled rock fragments indicative of recently deposited material were evident at one sampling location.

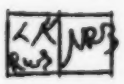
Echo sounding and a side scan sonar survey did not identify piles of rock and soil indicative of recently dumped material, although areas of potential dumped material were identified in the vicinity of the approved dumpsite and the biological sampling site.

Substrate per cent organic content was higher in the post-dump survey than in the pre-dump surveys. The increase is probably attributable to natural variability since the per cent organic content also increased at a sampling location approximately 1.5 km east of the dump site and out of the predominant current flow. Sedimentation rates were generally uniform between pre- and post-dump surveys. The post-dump organic content was slightly greater than spring pre-dump levels but less than fall pre-dump levels.

Zoobenthos densities were similar and typical of the Bruce GS 'B' site during pre- and post-dump surveys. Members of the Oligochaeta and Diptera taxa were the predominant zoobenthic organisms present.

Fish were most abundant during spring pre- and post-dump surveys. Alewife and smelt, pelagic spring spawning species, were the predominant spring species. The number of burbot collected increased in the post-dump study. However, their increase probably reflected natural population variation rather than a disposal effect.

Overall no related effect on the measured physical, chemical and biological parameters at the biological dump site could be attributed to the disposal of excavation material at the approved dump site location.



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To Mr. C.W. Dawson
Section Head
Environmental Sciences and Technology
Design and Development Division

BRUCE GS 'B' DUMP SITE STUDY
1982 RESULTS AND
SUMMARY REPORT FOR 1977-1985

1.0 INTRODUCTION

Ontario Hydro received approval from Transport Canada for specific construction and reclamation activities along the Lake Huron shoreline fronting Bruce GS 'B' in February 1977. The excavation and disposal of dredged materials from the Bruce GS 'B' intake and discharge channels required further approval after input from the Ontario Ministry of Natural Resources (OMNR). OMNR responded in June 1977, detailing three suitable locations for dumping the dredged materials. One location acceptable to OMNR and Ontario Hydro was in water greater than 37 m in depth beyond a former lake trout spawning ground approximately due west of the Bruce GS 'B' site (OMNR, 1968). Transport Canada therefore approved the disposal of dredged materials in a rectangular area approximately 300 m (1000 ft) N-S by 90 m (300 ft) E-W centered on coordinates 44° 18' 54" N latitude and 81° 38' 17" longitude.

OMNR required Ontario Hydro to implement a study to monitor the fish community in the vicinity of the dump site prior to and after the dumping to assess fish response to the new substrate and topography as a condition for dumping approval. Environmental Studies and Assessments Department therefore requested Biological Research Section to initiate a dump site biological study in the fall of 1977.

Initially, four pre-dump (October 1977, May 1978, October 1978 and May 1979) and four post-dump (October 1981, May 1982, October 1982, and May 1983) sampling periods were scheduled, with the major emphasis on fish community studies. Surveys were to be conducted at the disposal site and at a control site

approximately 2 km south near Gunn Point. The October (fall) 1977 survey was completed as originally proposed (Ontario Hydro Research Division Report No C78-64-K). The dump site program was altered following this initial study as follows:

1. The May 1978 survey (Ontario Hydro Research Division Report No C78-181-K) was modified to increase the emphasis on benthic organisms and substrate evaluation in response to suggestions by OMNR (Lovering 1977).

2. The scope of the October 1978 and May 1979 surveys was changed following analysis of the previous survey data and to incorporate OMNR recommendations (Dunford 1978; Carthew 1978). The program alterations included:

   a) deletion of the biological control dump site area as it was unlike the dump site area in substrate related aspects (Ontario Hydro Research Division Report No C81-19-K)

   b) redesign of the dump site study area along two transects through the disposal area to describe sedimentation, substrate and zoobenthos before and after dumping (Ontario Hydro Research Division Report No C81-19-K)

   c) increased sampling effort for benthic organisms (triplicate samples at all sites) and fish (addition of 2.54 cm (1.0 in) gill net mesh, Ontario Hydro Research Division Report No C82-52-K).

3. The post-dumping survey schedule was revised as follows:

   a) The October 1981 survey was eliminated as dumping was to have continued through the sampling period (Dunford 1978).

   b) The October 1982 and May 1983 surveys were cancelled with the agreement of the Ontario Ministry of Environment (OMOE) and OMNR as the May 1982 survey results indicated minimal environmental impact (Gowans 1982).

   c) An underwater survey of the substrate at the dump site by commercial divers was requested by OMOE (McTavish July 26, 1982). The survey was scheduled for September, 1982 and was to include diver observations and substrate photographs.

A total of 45 870 m^3 of compacted glacial till and blasted rock was removed from the discharge and intake areas during 1979 and 1981 and transferred to the disposal site. Dumping of material

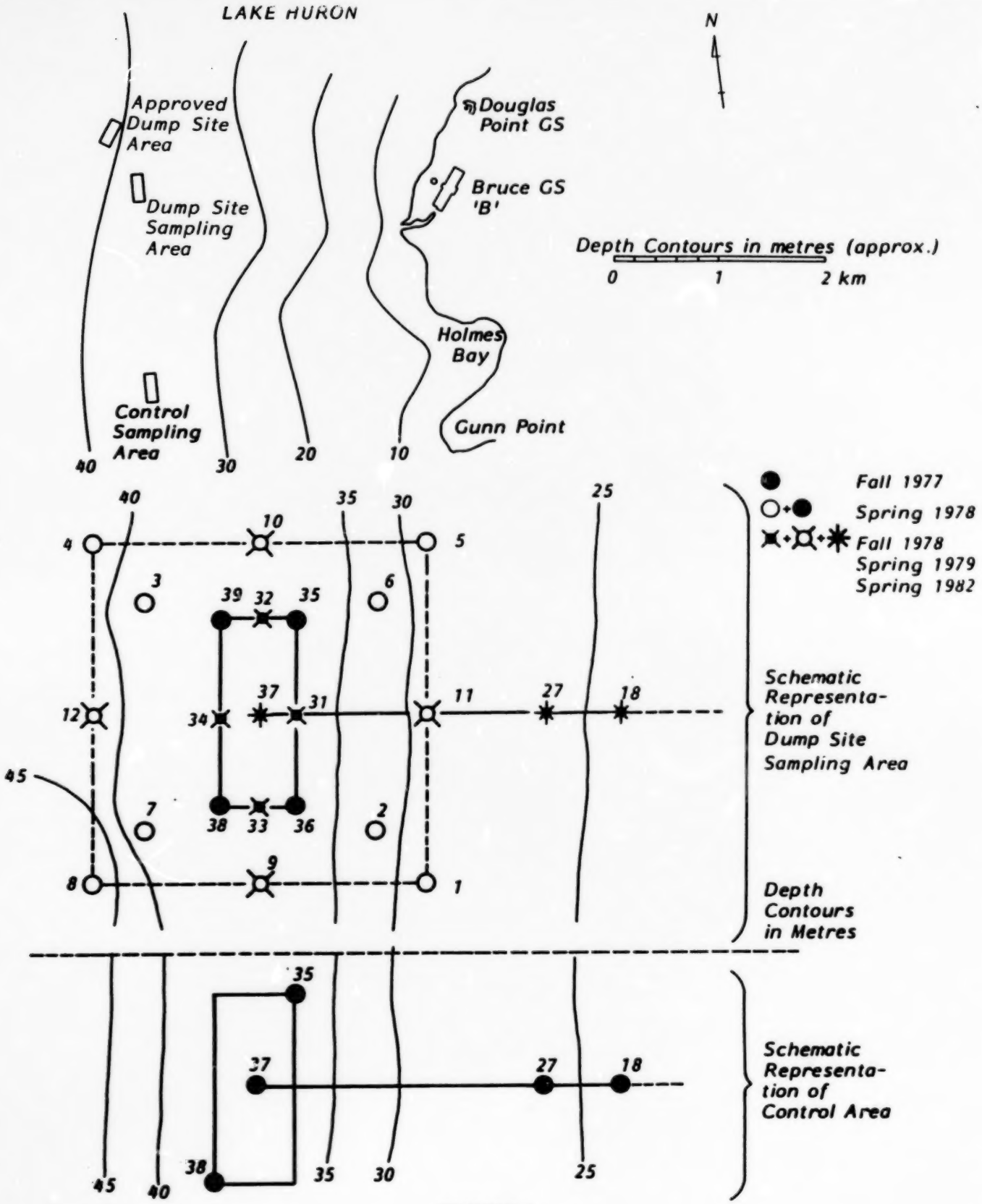


FIGURE 1

BIOLOGICAL SAMPLING SPAR LOCATIONS AT THE BRUCE 'B' DUMP SITE AND CONTROL AREA, FROM FALL 1977 TO SPRING 1982

excavated from the discharge area began in May, 1979 and continued through September, 1979. Dumping of overburden and blasted rock from the intake excavation took place between May and September of 1981. All dredged material was to be released from a slowly moving dump scow upon arrival at the disposal site.

During final report preparation it was determined that the biological dump site sampling area was approximately 488 m (1600 ft) due south of the approved disposal area. The biological sampling area was also centered around the 37 m depth contour (Ontario Hydro Research Division Report No C78-64-K) while the approved disposal area was centered around approximately the 40 m depth contour. Therefore biological surveys were conducted in an area outside the zone of approved dredged material disposal.

Ontario Hydro Surveys and Mapping subsequently completed an echo sounding survey within the vicinity of the disposal area in June 1984 as required by Transport Canada (Gowans, 1984). This survey did not conclusively identify areas of dumped material. ES&A therefore initiated a side scan sonar study of the near shore to 45 m depth lake bottom to locate the disposed material (Personal Comm. Gowans and Maher, Ontario Hydro). The study was conducted by a consultant in September 1985. Geotechnical and Hydraulics Engineering Department (Ontario Hydro) reviewed the consultant's data interpretation at the request of ES&A (Gowans, 1986).

This report presents the results of the 1982 survey (post-dump) and summarizes the results of the 1977-85 dump site studies. The effects of dumping excavated material are discussed in relation to the pre-dumping environment and biological sampling location.

2.0 MATERIALS AND METHODS

Dump site study sampling locations (dump site and control site) were marked yearly with aluminum scientific spar buoys (2.7 m long x 0.1 m diameter) to which a number was assigned. The 1977-82 spar locations are presented in Figure 1. Following the spring 1978 study, the sampling area was redesigned, with sampling points 35, 36, 38 and 39 shifted to new locations, but retaining the same location numbers. For the purposes of this report, however, these four locations (35, 36, 38 and 39) have been renumbered (31, 32, 33, and 34, respectively) (Figure 1) to avoid confusion when analyzing and discussing results. Sampling at each spar location is presented in Table 1 while fish sampling locations are presented in Figure 2.
Details of sampling procedures follow.

TABLE I

SAMPLING LOCATIONS
BRUCE 'B' DUMP SITE STUDY
1977-1982

Sampling Location (Spar No)		1977	1978		1979	1982	
		Fall	Spring	Fall	Spring	Spring	Fall
Control	18	S*					
	27	S*					
	35	B*	B*				
	37	S*B*C	B*C				
	38	B*	B*				
Dump Site	1		B				
	2		B				
	3		B*				
	4		B*				
	5		B				
	6		B				
	7		B				
	8		B*				
	9		B	S*B	S*B	S*B	
	10		B	SB	SB*	S*B*	
	11		B	SB	S*B	S*B	
	12		B	S*BC	S*B*	S*B	
	18	S		S*	S*B	S*B*	
	27	SC	C	SC	S*B	S*B	
	31			S*B	S*BC	S*B*C	D*
	32			SB*	S*B	S*B	D
	33			S*B	SB*	S*B	D*
	34			SB*	SB*C	S*BC	D
	35	B*	B				
	36	B	B				
	37	SB*C	BC	S*C	S*C	S*C	D
	38	B*	B				
	39	B*	B*				

S - Sedimentation
B - Substrate and Zoobenthos
C - Water Chemistry (all samples obtained)
D - Diver Observations
* - Sample Obtained

2.1 Water Chemistry

Water samples were collected with a 4 L PVC Van Dorn sample bottle within 1 m of the bottom at the locations and times presented in Table 1, Figure 1. Samples were preserved and stored according to the guidelines in Ontario Hydro Research Division Report No 78-285-K.

Analytical Services Section of the Chemical Research Department analyzed the water samples for the parameters listed in Table 2. Turbidity, pH, dissolved organic content (DOC) and soluble silica were the only parameters determined on all sampling dates.

Secchi disc measurements were recorded May 14, 1982 at spars 35, 37 and 39.

2.2 Substrate and Zoobenthos

Ponar dredge samples, each sampling 225 cm^2 of surface area were attempted at the locations and times presented in Table 1, Figure 1. Duplicate hauls were performed at the control and dump site sampling locations in the fall of 1977 and spring of 1978. Triplicate dredge samples were attempted on all other sampling occasions.

All organisms were sorted from each substrate sample and preserved. Benthic organisms were separated by groups, counted and identified to the species level where possible. The remaining substrate material was dried, weighed and analyzed for particle size (wet sieve method) and per cent organic content (estimated as loss-on-ignition at 550°C).

Visual observations and photographs of the substrate by commercial SCUBA divers at five locations within the dump site sampling area (31, 32, 33, 34 and 37) were scheduled for August 1982. Visual observations of the substrate components were obtained in circular area extending 10 m from the spar anchors. Photographs were taken randomly through this area with a Nikonos 35 mm underwater camera loaded with 200 ASA Ektachrome film. An electronic flash unit was used as a light source and photographs were taken at a distance of 0.8 m from the bottom.

Estimates of per cent cover of substrate components (cobble, boulder, etc) were determined visually, and from slides of the bottom substrate. In the latter case, substrate particle sizes were determined from a 20% projected area of each slide (Ontario Hydro Research Division Report No 83-182-K). The slides were also examined for evidence of any dredged material.

TABLE II

WATER CHEMISTRY ANALYSIS
1977-1982

Parameter	1977	1978		1979	1982
	Fall	Spring	Fall	Spring	Spring
pH	✓	✓	✓	✓	✓
Turbidity	✓	✓	✓	✓	✓
Carbon					
i) Total Dissolved	✓	✓	✓		
ii) DIC as C	✓	✓	✓		
iii) DOC as C	✓	✓	✓	✓	✓
iv) TOC as C				✓	✓
Suspended Solids					
105°C				✓	✓
550°C				✓	✓
Phosphorus					
i) Total as P	✓		✓	✓	✓
ii) Soluble as P	✓	✓			
iii) Orthophosphate				✓	✓
Nitrogen					
i) Total Kjeldhal		✓	✓	✓	✓
ii) Soluble as N	✓	✓			
iii) Nitrate as NO_3	✓			✓	✓
Silica					
i) Total			✓		
ii) Soluble	✓	✓	✓	✓	✓
Calcium	✓		✓	✓	✓
Magnesium	✓		✓	✓	✓
Chlorophyll a and phaeophytin			✓		

Surveys and Mapping Department repeated an echo sounding survey in the general area of the approved dump site as required by Transport Canada. The sounding lines previously run in 1975 were duplicated in June 1984 using a Raytheon 719 echo sounder. Bottom profiles produced from the 1984 soundings (Dwg. No. NK29-DXH-10160-0016 R1) were then compared to the 1975 bottom contours (Plan NK29-DXH-10160-0014 R0). W. Prior, a Geophysical consultant subsequently performed a side scan sonar survey from the nearshore to 45 m depth in the vicinity of Bruce GS 'B' to identify areas of disposed material. The survey was conducted September 23 to 27, 1985. Windy weather and rough lake conditions were experienced during the survey.

Approximately 91 km of continuous survey line segments were completed within the 7.5 km^2 study area using a Klein 531 T side scan sonar unit with 100 m of cable and a 500 kH_2 towfish. The survey data was interpreted by the consultant and reviewed by Geotechnical and Hydraulic Engineering Department. Areas of possible dumped material were identified and plotted.

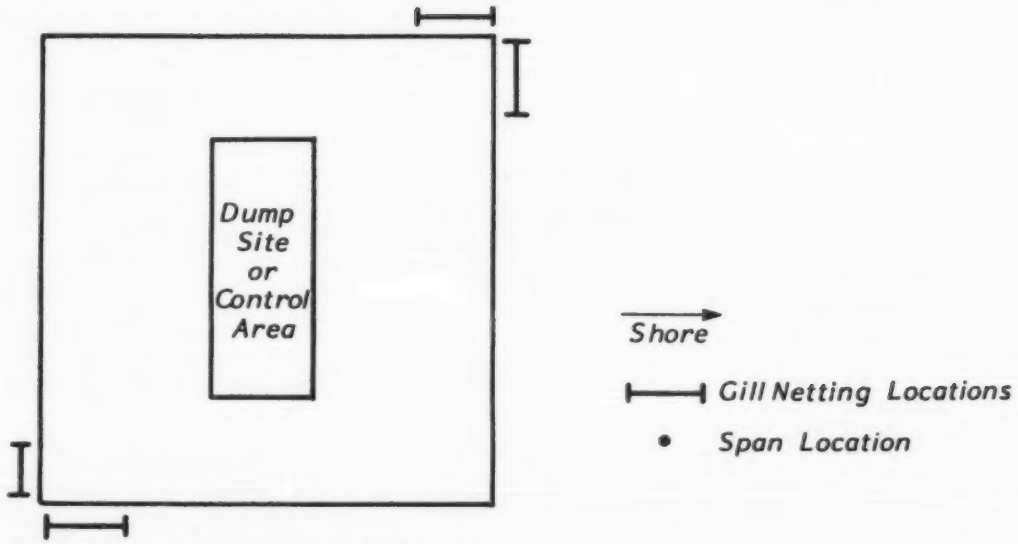
2.3 Sedimentation

Sediment tube racks, each containing four sediment tubes (each 61 cm long by 5 cm internal diameter PVC pipe) were placed at the locations and times presented in Table 1, Figure 1. The fall 1977 sediment tubes were installed in October. Each rack was equipped with a float line rising to within 10 m of the lake surface and 75 m of grappling target line stretching between the rack and an anchor. The tubes were to be retrieved in the spring of 1978. Sediment tube racks were set and retrieved in August and October and May and August in the 1978 and 1979 pre-operational studies, respectively. Post-operational study sediment tube racks were set and retrieved in May and August 1982, respectively.

All samples were allowed to settle for one hour, oven dried at 105°C for 24 hours, weighed, then ashed at 550°C for one hour and weighed to obtain ash-free weights and per cent organic content (estimated as loss-on-ignition).

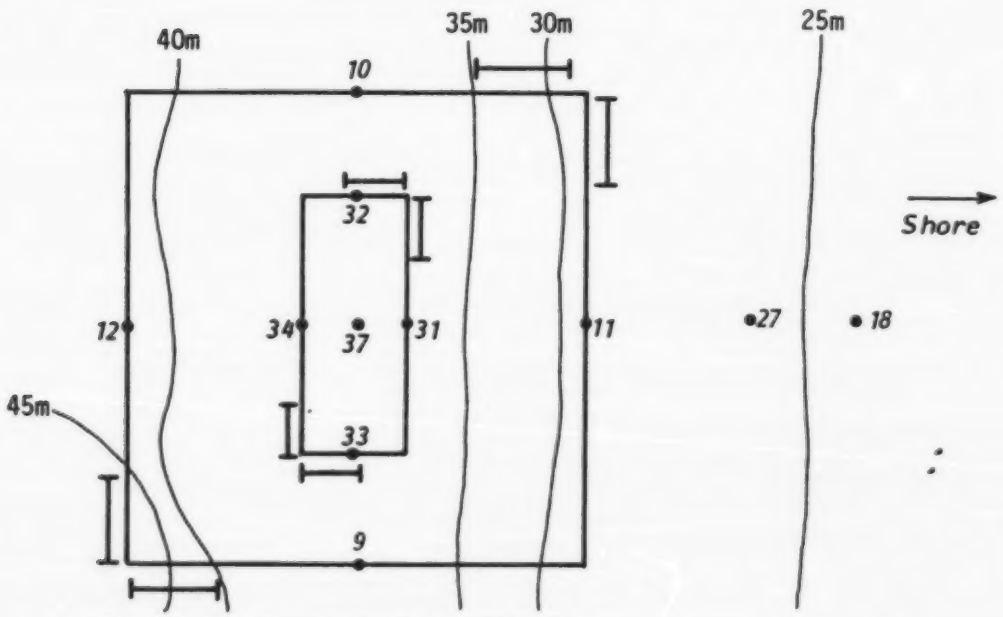
2.4 Fish Studies

Bottom gill nets were set at the locations and times presented in Figure 2. The fall 1977 and spring 1978 nets (four nets each period) consisted of 37 m panels of netting arranged in gangs of 3.8, 6.3, 8.9 and 11.4 cm mesh or 5.1, 7.6, 10.2 and 12.7 cm mesh. Eight gangs of nets were set in the fall of 1978, spring of 1979 and spring of 1982, respectively. Each gang consisted of 15 m (50 ft) panels of mesh arranged in the same manner as described above, except for the addition of 2.5 cm (1.0 in) mesh in the 5.1 - 12.7 cm mesh gangs.



Each Gang Approximately 148M Long

Fall 1977 and Spring 1978



Each Gang Approximately 60M Long

Fall 1978, Spring 1979 and Spring 1982

FIGURE 2

GILL NETTING LOCATIONS AT BRUCE GS'B' DUMP SITE

Each gang was set for two consecutive 24 hour periods in the spring of 1979 and 1982. Two sets of two consecutive 24 netting periods were conducted in the 1977 and 1978 studies. All fish caught were identified and enumerated. All adult fish were examined for spawning condition.

3.0 RESULTS AND DISCUSSION

3.1 Water Chemistry

Results of 1982 post-dump water chemistry analysis are presented in Table III in association with pre-dumping water chemistry data from 1977 to 1979. Values for the parameters measured were quite similar between locations and over the course of the study (1977-1982) with some exceptions. No water samples were collected during the dumping period.

The pH values ranged from 8.3 in the fall of 1977 to 7.5 in the spring of 1982. A comparison with pH measurements obtained at the 12 m depth at the Bruce GS 'B' intake from 1979 to 1981 (Table IV and Ontario Hydro Research Division Report Nos 83-182-K, 82-205-K, 83-451-K) indicates that similar values (7.6-8.4) were obtained. During previous sampling at seven lake stations between MacGregor Point (Port Elgin) and the Saugeen River (Southampton) in 1974 and 1975 by the Ontario Ministry of Environment, pH values ranged from 7.6 to 7.8 (Ross and Chatterjee 1977, Table IV). Thus the values obtained in this study are considered to be within the realm of normal lake H^+ ion concentration fluctuations.

Turbidity values ranged from 0.3 to 1.7 NTU over the course of the study with the highest values reported for the post-dump period (1982). All values, however, are relatively low as would be expected of deep (27-39 m) Lake Huron bottom water samples. These values are similar to those obtained from samples collected near the bottom at the 12 m location at the Bruce GS 'B' intake between 1979 and 1981 (mean - 1.0 NTU, range 0.5-1.7 NTU, Table IV). Higher values were obtained by the OMOE at seven surface water sampling locations between MacGregor Point (Port Elgin) and the Saugeen River (Southampton) during 1974 and 1975 (mean 2.0 NTU, range 1.0-7.4 NTU, Table IV).

Dissolved inorganic carbon was measured three times only in pre-dump surveys between fall 1977 and fall 1978. Concentrations ranged from 18.8 to 210 mg/L. Dissolved organic carbon (DOC) values ranged from 1.0 to 4.0 mg/L over the course of the study with no major differences between the pre- and post-dump survey values. The DOC value (4.0 mg/L) recorded at spar D34 during the 1982 post-dump survey is greater than the total organic content value recorded for the same sample

TABLE III

BRUCE GS 'B' DUMP SITE WATER CHEMISTRY RESULTS
1977 - 1982

Parameter	1977 Fall			1978 Spring			1978 Fall			1979 Spring			1982 Spring		
	C37†	D27†	D37	C37	D27	D37	D12	D27	D37	D31	D37	D34	D31	D37	D34
pH	8.3	8.3	8.3	8.0	8.2	8.0	7.6	7.7	7.8	7.8	7.8	7.8	7.5	7.5	7.5
Turbidity	1.0	1.0	1.2	0.5	0.7	1.0	0.3	0.5	0.4	0.7	1.0	0.7	1.7	1.5	1.5
Carbon (mg/L)															
i) Total Dissolved	22.7	22.6	22.7	20.7	21.1	20.8	21.4	21.0	21.2	-	-	-	-	-	-
ii) DIC as C	20.8	21.0	21.0	18.8	18.9	19.3	19.9	19.9	19.9	-	-	-	-	-	-
iii) DOC as C	1.9	1.6	1.7	1.9	2.2	1.5	1.5	1.1	1.3	2.2	2.5	3.0	1.0	2.0	4.0***
iv) TOC as C	-	-	-	-	-	-	-	-	-	2.2	3.2	3.3	3.0	3.0	3.0
Suspended Solids (mg/L)															
105°C	-	-	-	1.2	1.2	1.4	-	-	-	3.4	3.4	2.2	2.8	1.6	2.6
550°C	-	-	-	-	-	-	-	-	-	2.2	2.8	2.0	<0.5	<0.5	1.0
Phosphorus (mg/L)															
i) Total as P	<0.01	<0.01	<0.01	-	-	-	<0.01	<0.01	<0.01	0.032	0.043	0.033	0.017	0.008	0.010
ii) Soluble as P	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-	-	-	-	-	-
iii) Orthophosphate	-	-	-	-	-	-	-	-	-	<0.01	<0.01	<0.01	0.008	0.007	0.007
Nitrogen (mg/L)															
i) Total Kjeldhal	-	-	-	0.17	0.15	0.15	0.14	0.34	0.20	0.09	0.20	0.20	0.1	0.1	0.1
ii) Soluble as N	<0.1	<0.1	<0.1	0.13	0.12	0.12	-	-	-	-	-	-	-	-	-
iii) Nitrate as NO_3	0.75*	0.89*	0.71*	-	-	-	-	-	-	1.59	1.28	1.48	3.1**	1.6	1.6
Silica (mg/L)															
i) Total	-	-	-	-	-	-	1.56	1.60	1.30	-	-	-	-	-	-
ii) Soluble	1.34	1.24	1.25	1.3	1.3	1.3	1.25	1.28	1.28	1.26	1.35	1.43	1.5	1.0	1.3
Calcium (mg/L)	24.5	23.0	24.0	-	-	-	27.9	27.8	27.6	28.5	28.5	28.5	27.0	30.0	29.0
Magnesium (mg/L)	6.5	6.4	6.5	-	-	-	7.0	7.1	7.0	6.8	6.8	6.8	7.0	7.1	7.2
Chlorophyll a and phaeophytin	-	-	-	-	-	-	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	-	-	-	-	-	-

†C = Control
†D = Dump Site

* - Corrected on molecular weight basis to yield mg NO_3/L
** - Contaminated sample (Analytical Services)
*** - Within error limit of analytical method (1 mg/L) (Analytical Services)

TABLE IV

COMPARISON OF WATER CHEMISTRY DATA COLLECTED
BY OMOE (ONTARIO MINISTRY OF ENVIRONMENT) AND ONTARIO HYDRO, 1973-1982

Parameter	Dump Site Control 1977-78	Dump Site 1977-79	Dump Site 1982	MOE Pt Elgin-Southhampton 1974-75	Bruce B Intake 12 m Bot 1979-81
pH	8.2 (8.0-8.3)	7.9 (7.6-8.3)	7.5 (7.5)	7.7 (7.6-7.8)	8.1 (7.6-8.4)
Turbidity (NTU)	0.8 (0.5-1.0)	0.7 (0.3-1.2)	1.6 (1.5-1.7)	2.0 (1.0-7.4)	1.0 (0.5-1.7)
Carbon (mg/L)					
i) Total Dissolved	21.7 (20.7-22.7)	21.6 (20.8-22.6)			
ii) DIC as C	19.8 (18.8-20.8)	20.0 (18.9-21.0)			
iii) DOC as C	1.9 (1.9)	1.9 (1.0-3.0)	2.0 (1-3)		
iv) TOC as C		2.9 (2.2-3.2)	3.0 (3.0		1.1 (<1 - 1.9)+
Suspended Solids (mg/L)					
105°C	1.2	2.3 (1.2-3.4)	2.3 (1.6-2.8)		1.7 (0.6-5.2)
550°C		2.3 (2.0-2.8)	0.6 (<0.5-1)		0.9 (0.4-2.7)
Phosphorus (µg/L)					
i) Total as P	10	19 (<10-43)	12 (8-17)	11 (6-20)	9 (5-19)+
ii) Soluble as P	10 (10)	<10		(1-4)	7 (<5-13)+
iii) Orthophosphate		<10	7 (7-8)		7 (<2-12)+
Nitrogen (mg/L)					
i) Total Kjeldhal	0.17	0.18 (0.09-0.34)	0.1 (0.1)	(0.11-0.26)	0.30 (0.12-0.78)+
ii) Soluble as N	0.11 (<0.1-0.13)	0.1 (<0.1-0.12)			0.24 (0.09-0.53)+
iii) Nitrate as NO_3	0.75*	1.19 (0.71-1.59)*	1.6 (1.6)	(0.25-0.33)	1.20 (0.86-1.8)+
Silica (mg/L)					
i) Total		1.5 (1.3-1.6)			1.6 (1.3-1.9)+
ii) Soluble	1.3 (1.3)	1.3 (1.2-1.4)	1.3 (1.0-1.5)	1.3 (1.1-1.5)	1.0 (0.5-1.5)+
Calcium (mg/L)	24.5	27.0 (23.0-28.5)	28.7 (27.0-30.0)		26.3 (24.8-28.0)+
Magnesium (mg/L)	6.5	6.8 (6.4-7.1)	7.1 (7.0-7.2)		7.1 (6.8-7.3)+

(3.0 mg/L) but is within the detection (error) limit of the analytical method (1 mg/L, Analytical Services). Total organic carbon (TOC) was measured only in 1979 and 1982. Values were similar between the pre- and post-dump surveys ranging from 2.2 to 3.3 mg/L. Overall, the dump site TOC levels are slightly higher than levels recorded at the Bruce GS 'B' intake 12 m bottom (<1 to 1.9 mg/L 1979-1981, Table IV).

Total phosphorus concentrations were less than 0.017 mg/L for most sampling years with the exception of 1979 when values ranged from 0.032 to 0.043 mg/L. These values are probably expressed as PO_4 rather than as P (H. Medhi, Analytical Services, personal comm). Expressing these values as P (0.010 to 0.014 mg/L) would bring them within the range of other values reported for this study. The dump site total phosphorus values are similar to values recorded at Bruce GS 'B' intake 12 m bottom during 1979 and 1981 (0.005 to 0.019 mg/L, Table IV), and surface water samples collected between Port Elgin and Southampton in 1974-75 (0.006 to 0.020 mg/L, Table IV).

Soluble phosphorus and orthophosphate concentrations remained below 10 µg/L during the pre- and post-dump studies. These concentrations are similar to soluble phosphorus ($\bar{X}$ = 7 µg/L) and orthophosphate ($\bar{X}$ = 7 µg/L) concentrations at the Bruce GS 'B' 12 m intake bottom in 1979 and 1981 (Table IV).

Pre-dumping Kjeldhal nitrogen values ranged from 0.1 to 0.3 mg/L. Post-dumping concentrations were 0.1 mg/L at all sampling locations. These values are similar to 1979 and 1981 concentrations at the 12 m location at the Bruce GS 'B' intake (0.1 to 0.8 mg/L; Table IV). Nitrate nitrogen concentrations ranged from 0.7 to 1.6 µg/L during pre-dumping studies while post-dumping concentrations were 1.6 mg/L. Similar nitrate nitrogen values were recorded during 1979 and 1981 at the Bruce GS 'B' 12 m intake bottom sampling location (0.7 to 1.8 mg/L, Table IV).

Soluble silica concentrations ranged from 1.0 to 1.5 mg/L over the course of the study with no apparent trends. These values are similar to those obtained by the OMOE during 1974 and 1975 near Port Elgin (1.1 to 1.5 mg/L, Table IV).

Calcium concentrations ranged from 23.0 to 30.0 mg/L which are similar to values obtained at the 12 m location at the Bruce GS 'B' intake during 1979 and 1981 (24.8 to 28.0 mg/L, Table IV). Magnesium concentrations ranged from 6.4 to 7.2 mg/L. Again, these values are similar to those obtained at the 12 m depth at the Bruce GS 'B' intake during 1979 and 1981 (6.8 to 7.3 mg/L, Table IV).

Secchi disc measurements recorded during 1982 water chemistry sampling were 11.0 m (spar 31), 9.5 m (spar 37) and 10.5 m (spar 34). These values are similar to Secchi disc measurements made on July 7, 2000 m from the Bruce GS 'B' shoreline (7.5 to 11.5 m, Ontario Hydro Research Division Report No 83-451-K).

Water quality parameters measured at the control and dump site prior to dumping and at the dump site after dumping are similar throughout the study. All differences are within the range of normal seasonal and yearly fluctuations as reported in studies by OMOE during 1974 and 1975 (Ross and Chatterjee 1977) and Ontario Hydro Bruce GS 'B' pre-operational surveys (Ontario Hydro Research Division Report Nos 82-205-K, 83-182-K and 83-451-K). All parameters reflect the oligotrophic nature of Lake Huron (Kwiatkowski 1980).

3.2 Substrate

The substrate particle size analysis results from pre-dump surveys (1977-79) and the post-dump survey (1982) are presented in Table V.

A brief comparison of substrate composition between the control and dump site locations revealed that approximately 85% of the particles at the control location were in the clay, silt and fine sand (0.002 to 0.25 mm) size range, with coarse sand (0.25 to 2.0 mm) and gravel (2 to 16 mm) comprising the remaining portion (12% and 2% respectively) (Table V). At the dump site during fall 1977 and spring 1978 pre-dump surveys, sand comprised approximately 52% of the substrate with clay, silt and fine sand particles and gravel comprising 17% and 30%, respectively (Table V). Results of the 1979 spring pre-dump surveys indicated gravel was the predominant substrate component (51%) at the dump site with coarse sand (29%) and clay, silt and fine sand (20%) fractions in lesser amounts.

Sample retrieval at the dump site was considerably less (37%) than at the control area (83%), indicating the presence of larger particles which could not be effectively sampled with the ponar dredge. Difficulty in obtaining samples was again encountered during fall 1978 and spring 1979 survey at the dump site. Sample recovery for these two surveys averaged 25%, again indicating the presence of larger substrate particles. The previous decision to discontinue sampling at the control location (Ontario Hydro Research Division Report No C81-19-K, Appendix A), due to differences in substrate composition, appears justified.

Considerable variation in substrate composition was evident at the pre-dump dump site sampling location from 1977-79

SUBSTRATE PARTICLE SIZE ANALYSIS (PER CENT COMPOSITION)
BRUCE GS 'B' DUMP SITE SURVEYS
1977-1982

Location Spar Number	Pre-Dump Surveys															Post-Dump Surveys					
	1977			1978						1979			Overall			1982			Overall		
	Fall			Spring			Fall			Spring			$\bar{X}$			Spring			$\bar{X}$		
	G	S	C	G	S	C	G	S	C	G	S	C	G	S	C	G	S	C	G	S	C
Control 35	-	4.3	95.7	-	4.6	95.4															
37	-	7.0	93.0	-	4.9	95.2							2.3	12.3	85.4						
38	13.8	35.4	50.8	-	15.5	84.6															
$\bar{X}$	4.6	15.6	79.8	-	8.3	91.7															
Dump Site 3				11.1	28.0	60.8															
4				30.7	36.4	32.8															
8				4.3	33.2	62.5															
10				97.7	1.6	0.8				6.9	8.4	84.6				20.4	76.8	3.4			
12				17.6	76.8	5.7				41.4	53.8	4.7									
18																17.1	75.3	7.6	32.5	64.5	3.0
27										73.7	22.8	3.5									
32							0.5	11.5	88.0				28.4	44.3	27.4	59.8	39.4	0.3			
33										96.0	1.5	2.5									
34							8.9	25.5	65.6	37.2	56.2	6.6									
35	16.9	69.8	13.3																		
36																					
37	35.8	56.7	7.5				13.0	22.4	64.6							32.7	66.3	0.8			
38	-	79.3	20.7																		
39	1.0	82.6	16.4	2.8	54.5	42.7															
$\bar{X}$	13.4	72.1	14.5	27.4	38.4	34.2	7.5	19.8	72.7	51.0	28.5	20.4				32.5	64.5	3.0			

G - Gravel - 2 - 16 mm
S - Sand - 0.25 - 2.0 mm
C - Clay - 0.002 - 0.25 mm

(Table V). Similar variation was apparent in the 1982 post-dump dump site substrate composition results. Coarse sand (39 to 77%) was predominant with gravel (17 to 60%) and silt, fine sand (0 to 8%) in lesser amounts. These variations can be attributed to sampling error (i.e. the low overall sample recovery success, the small sampling area of the ponar dredge) and the natural substrate variability (Appendix 1). Therefore changes in substrate composition between pre-dump (1977-79) and post-dump (1982) surveys should not be attributed to dumping of dredged materials.

SCUBA diver observations of substrate composition and substrate photographs were obtained in September, 1982 at locations 31 and 33. Adverse weather conditions prevented two previous attempts and limited the final attempt to two locations only before safety considerations (decompression) cancelled dives at the remaining locations. Results of analysis of these photographs are presented in Appendix 1 and condensed in Table VI. Representative photographs from each location are shown in Figure 3.

Analysis of photographs from location 31 (n = 19) indicates that particles in the cobble size range (64-256 mm) were the most abundant (38% of bottom cover), followed closely by clay, silt and fine sand particles (36%). The remainder of the substrate consisted of particles in the pebble (8-64 mm) size range (22%), and boulder (>256 mm) size range (4%).

TABLE VI

SUBSTRATE COMPOSITION FROM PHOTOGRAPHS
BRUCE 'B' DUMP SITE, 1982

Location	Boulder	Cobble	Pebble	Gravel	Clay,Silt,Sand
31	4	38	22	-	36
33	39	27	17	1	16

Visual observations by the divers indicated that fine particles (sand, clay and silt) comprised the majority of the bottom substrate (approximately 95%) with larger particles averaging 2-3 cm in size making up the remainder. These observations overestimate the fine particle fractions when compared with the photograph analyses (Appendix 1). The visual observations are dependent on the diver's ability to estimate the substrate composition within a 10 m circle while the photographs are indicative of the actual substrate.

SPAR 31

SPAR 33

FIGURE 3
SUBSTRATE PHOTOGRAPHS BRUCE 'B' DUMPSITE, 1982

87-174
173136 RD

Analysis of photographs from location 33 (Table VI, n = 14) indicates that substrate consisted mainly of boulder (39%) and cobble (27%), with approximately equal parts of pebble and clay, silt and fine sand (17 and 16% respectively). Visual observations by the divers indicated that boulder, cobble and pebble comprised approximately 50% of the bottom substrate, with sand, clay and silt present in the other half. Boulders to a maximum size of 1.2 m in length and 0.9 m in diameter were observed by the divers at this location. These observations are generally in agreement with the substrate photographs, although fine particles again seem to be overestimated.

A small number of sharp angled rock fragments indicative of recently deposited material were evident upon the substrate at location 33 as shown in Figure 3. The SCUBA divers reported no obvious evidence of dumping at either sampling location.

Analysis of the 1975 and 1984 echo sounding profiles in the vicinity of Bruce GS 'B' and approved dump site location did not indicate areas of disposed material. All topographical changes between the 2 survey profiles were within the range of error for the echo sounding technique (Gowans 1984).

The interpreted side scan sonar data did not conclusively indicate areas of dumped material (Grass and Bowlby 1986). This may be due to the reworking of the disposed material by natural lake forces (i.e. ice keels and currents) during the 4 to 6 year period between dumping and the side scan sonar survey. Four potential disposal sub-areas were delineated within the study area (Figure 4 attached to back cover). These sub-areas were characterized by anomalous features relative to the surrounding substrate. Sub-areas B and C are in the vicinity of the approved dump site with sub-area B adjacent to the biological sampling site. Sub-area A is situated approximately 1,000 m from the approved dump site.

The per cent organic content of bottom substrate samples collected in 1977-1982 are presented in Table VII. The organic content of pre-dump control and dump site substrate samples remained below 2.0% with a mean value of 1.2%. The mean organic content of spring pre-dump dump site samples was 1.3%. Organic content in post-dump surveys ranged from 3.5% at location 10 to 6.7% at location 32 with an overall mean of 5.6%. The increase in per cent organic content at the dump site may reflect natural variability. At location 10 the organic content increased by 72% between the spring of 1978 and 1979 in pre-dump surveys. The increase in per cent organic content between the spring 1979 surveys (pre-dump) and the spring 1982 survey (post-dump) was 84%. At location 18 approximately 1525 m (5000 ft) east of the dump site and out of the direction of predominant current flow

TABLE VII

ORGANIC CONTENT OF BOTTOM SUBSTRATE SAMPLES
AT BRUCE 'B' DUMP SITE
1977-1982

Year	Location		Per Cent Organic Content	Annual Mean
1982 Spring	Dump Site	10	3.5	5.6
		18	5.5	
		32	6.7	
		37	6.6	
1979 Spring	Dump Site	10	1.93	1.41
		12	1.77	
		27	0.04	
		34	1.88	
1978 Fall	Dump Site	32	1.28	1.05
		37	0.84	
		34	1.04	
1978 Spring	Control	35	0.78	1.01
		37	0.81	
		38	1.44	
	Dump Site	3	1.39	1.16
		4	0.80	
		8	0.95	
		10	1.05	
		12	1.50	
		39	1.28	
1977 Fall	Control	37	0.80	0.91
		38	1.01	
	Dump Site	35	0.98	0.98

(Ontario Hydro Hydraulic Studies and Development Department Report No 82393) the per cent organic content was 5.5% in the post-dump survey.

3.3 Sedimentation

The mean sedimentation rates at dump site survey locations from the fall of 1978 to spring 1982 are presented in Table VIII. Sediment tubes set at the dump site in the fall of 1977 were not recovered in the spring of 1978. Sediment tubes set at the control site at the same time were recovered (Table I) in a damaged condition, resulting in questionable data. These results can be found in Ontario Hydro Research Division Report No C78-181-K.

The mean daily sediment accumulation in 1982 ranged from 0.039 g/d at location 34 to 0.242 g/d at location 18 with an overall mean of 0.099 g/d for the dump site area. This was similar to 1979 results (mean - 0.101 g/day; range - 0.050 to 0.261 g/d) but was slightly lower than 1978 results (mean - 0.123 g/d; range - 0.079 to 0.212 g/d). The higher mean value for the fall of 1978 is not considered significant as only 50% of the sampling locations were represented and fall weather conditions are generally more disturbed, resulting in increased wave action and corresponding resuspension and deposition of particulate material. Higher mean sedimentation rates during the fall were also observed in sampling programs conducted at the Bruce GS 'A' site during 1979 and at the Bruce GS 'B' site during both 1979 and 1981 (Ontario Hydro Research Division Report Nos 82-107-K, 83-182-K and 83-451-K).

Sedimentation values were consistently higher at location 18 (shallowest sampling location) throughout the study. At greater depths, daily sedimentation was less than 0.13 g/d with only one exception (location 9; 1982, 0.206 g/d) over the study.

Per cent organic content of the sediment samples varied from 8.1 to 12.3% during spring 1982. This was slightly higher than the values obtained in spring 1979 (5.7 to 8.1%) and similar to fall 1978 values (9.1 to 15.0%).

Hence, sedimentation rates at the Bruce GS 'B' dump site were fairly consistent between 1978 and 1982. Mean daily sedimentation was generally less than 0.13 g/d beyond the 27 m depth contour. Organic content of samples ranged from 5.7 to 15.0%.

The excavation material disposed of at the dump site had been previously washed during both transfer from the excavation area to the dump scow and release from the dump scow to its final deposition on the lake bed at the dump site. This would result

TABLE VIII

MEAN SEDIMENTATION RATES (g/d)
1978-1982

Spar No	Depth (m)	Dry Weight			Ash Weight			% Organic Matter		
		1978 Fall	1979 Spring	1982 Spring	1978 Fall	1979 Spring	1982 Spring	1978 Fall	1979 Spring	1982 Spring
18	18	0.212	0.261	0.242	0.192	0.246	0.222	9.1	5.7	8.1
27	27	-	0.102	0.103	-	0.096	0.095	-	5.7	8.1
11	29	-	0.099	0.050	-	0.092	0.045	-	5.8	10.1
31	35	0.079	0.087	0.077	0.095	0.082	0.070	10.1	6.3	9.5
9	37	0.122	0.055	0.206	0.110	0.051	0.189	10.4	7.4	8.1
10	37	-	-	0.043	-	-	0.038	-	-	11.5
32	37	-	0.079	0.063	-	0.074	0.057	-	6.4	9.6
37	37	0.120	0.077	0.063	0.108	0.072	0.056	9.3	6.2	12.3
33	37	0.113	-	0.104	0.096	-	0.094	15.0	-	9.6
34	39	-	-	0.039	-	-	0.035	-	-	11.4
12	42	0.094	0.050	0.037*	0.085	0.045	0.032*	9.4	8.1	12.7*
Overall Mean		0.123	0.101	0.099	0.114	0.095	0.090	10.6	6.5	9.8

* - Partial sample loss

in much of the fine particulate matter being suspended in the water at the excavation area and over the dump site. The direction and velocity of lake currents in the dump site vicinity would influence the dispersal area and rate of fine sediment deposition. No sediment tubes were set during the dumping of the excavated materials. Resuspension of particulate matter would be minimal at the dump site in a water depth >37 m. Therefore the extent and range of dispersal of fine sediments is unknown.

3.4 Zoobenthos

Sample recovery at the dump site during 1982 was extremely poor with only six samples obtained at three locations out of a possible 33 samples at 11 locations. This was consistent with previous benthic surveys (1977-1979) in which difficulty was encountered in obtaining ponar dredge samples due to bottom type. Only 22 out of 125 sampling attempts were successful in retrieving bottom substrate from which benthic organisms were sorted during the pre-dump surveys. The particular locations where sampling was successful between 1977 and 1982 are shown in Table I.

In the 1982 post-dump survey, 24 benthic organisms were collected of which 54.2% were lumbriculid oligochaetes at a maximum density of 96.3 organisms/m^2 in soft substrate which comprised approximately 13% of the bottom as determined by ponar dredge recovery success. Other organisms collected included the amphipod, Pontoporeia affinis, isopod Asellus sp and the chironomids, Heterotrissocladius changi (8.3%, 14.8 organism/m^2, respectively) and Parakiefferiella sp (4.2%) and unidentified tubificid oligochaetes (12.5%). Listings of density and number of individual organisms are presented in Table IX and Appendix 2.

In pre-dump surveys (1977 - 1979), a total of 113 organisms were collected, of which 40.7% were chironomids, at a maximum density of 92.9 organisms/m^2 in soft substrate. Other organisms collected included tubificid oligochaetes (26.5%), amphipods (20.4%), sphaerid molluscs (6.2%) and lumbriculid oligochaetes (6.2%). Densities and total number of individual organisms are presented in Table IX and Appendix 3.

A comparison of pre- and post-dumping surveys indicates a decrease in per cent composition and density of chironomids (Diptera, 40.7% to 12.5%) and an increase in per cent composition of lumbriculids (Oligochaeta, 6.2% to 54.2%) after dumping (1982). However, these apparent shifts are considered questionable due to the variation between sites and replicates. The lowest chironomid per cent composition (0%) was recorded in

TABLE IX

COMPOSITION AND DENSITY OF ZOOBENTHIC ORGANISMS DURING PRE- AND POST-DUMP SURVEYS

Organism	Dump Site				Fall 1977 and Spring 1978			
	Pre-Dump 1977-1979		Post-Dump 1982		Control		Dump Site	
	% Composition	#/m^2	% Composition	#/m^2	% Composition	#/m^2	% Composition	#/m^2
Amphipoda	20.4	46.5	8.3	14.8	4.7	53.3	11.9	17.1
Isopoda	-	-	8.3	14.8	-	-	-	-
Diptera								
Chironomidae	40.7	92.9	12.5	22.2	61.7	693.3	42.9	61.5
Mollusca								
Sphaeridae	6.2	14.1	-	-	0.4	4.4	7.1	10.2
Oligochaeta								
Lumbriculidae	6.2	14.1	54.2	96.3	23.7	266.7	16.7	23.9
Tubificidae	26.5	60.6	16.7	29.6	9.5	106.7	21.4	30.8
Total	100.0	228.2	100.0	177.7	100.0	1124.4	100.9	143.5

the 1977 pre-dump survey (Appendix 3) while Lumbriculids comprised 50% of the benthic samples in the same pre-dump year.

Overall, densities during both pre- and post-dump surveys (228 and 178 organisms/m^2, respectively) were quite similar and were also similar to the mean density determined for the 12 m depth contour of the Bruce GS 'B' site in June 1979 (225 organisms/m^2) (Ontario Hydro Research Division Report No 83-182-K). Members of the Oligochaeta (66%) and Diptera (32%) were the most numerous zoobenthic organisms at the Bruce GS 'B' site during 1979 as well as during the dump site studies.

As previously noted, sampling at the control location was discontinued after the spring of 1978 since it was unlike the dump site in most substrate related respects (Ontario Hydro Research Division Report No C81-19-K, Appendix A). As shown in Table IX, composition of zoobenthic organisms was similar at both locations, but abundance was approximately an order of magnitude greater for the major groups (Chironomidae, Lumbriculidae) at the control location. Sample recovery at the control location was also much greater (~83%) than at the dump site (30%). The control area was also much more diverse, with 24 taxa represented compared to 12 taxa at the dump site. A complete list of zoobenthic organisms collected at the control and dump site locations during fall 1977 and spring 1978 is presented in Appendix 4.

3.5 Fish Studies

The fish catch data for the Bruce GS'B' dump site and control locations 1977-82 are presented in Table X.

Catch per unit effort (CUE) was calculated for each sampling period based on the fish catch resulting from a 24 h set of a standard net, consisting of eight 15.2 m (50') panels of gill net ranging in size from 3.8 cm (1.5") to 12.7 cm (5.0") in 1.3 cm (0.5") increments (Table X). Fish catch in 2.5 cm (1") mesh, which was employed only during the latest three sampling periods (fall 1978, spring 1979, spring 1982), is presented separately (Table XI).

A comparison of pre- and post-dumping phases at the dump site location revealed that total catch/unit effort (CUE) was considerably higher during the two spring pre-dump surveys (77.0 and 99.7 fish/net set, spring 1978 and spring 1979, respectively) than the fall surveys prior to dumping (17.1 and 13.1 fish/net set, fall 1977 and fall 1978, respectively) or the spring post-dump survey (23.9 fish/net set). The higher CUE during both spring 1978 and spring 1979 largely reflects the abundance of alewife present during both surveys during inshore alewife

TABLE X

FISH CATCH AT BRUCE GS 'B' DUMP SITE AND CONTROL LOCATIONS

1977 - 1982

Species	Control Location						Dumpsite Location															
							Number					% Composition					CUE*					
	Fall 1977			Spring 1978			1977	1978		1979	1982	1977	1978		1979	1982	1977	1978		1979	1982
	Number	% Composition	CUE*	Number	% Composition	CUE*	Fall	Spring	Fall	Spring	Spring	Fall	Spring	Fall	Spring	Spring	Fall	Spring	Fall	Spring	Spring
Yellow Perch	12	11.0	1.2				101	1	43		3	59.0	0.1	20.4		1.0	10.1	0.1	4.0	-	0.4
Longnose Sucker	58	53.3	5.8				30	2	35	1	11	17.5	0.3	16.6	0.1	3.6	3.0	0.2	3.1	0.1	1.4
White Sucker	3	2.8	0.3				7		5	5		4.1		2.4			0.7	-	0.4	-	-
Redhorse Sucker	2	1.8	0.2				2		3	3		1.2		1.4			0.2	-	0.3	-	-
Smelt	24	22.0	2.4	76	3.9	7.6	9	43	63	270	113	5.3	6.4	29.8	16.3	36.7	0.9	4.9	-	2.1	-
Lake Chub	1	0.9	0.1				6		27	1		3.5		12.8	0.1		0.6	-	2.5	-	-
Burbot	2	1.8	0.2				12	15	13	10	44	7.0	2.2	6.2	0.6	14.3	1.2	1.7	1.3	1.1	5.5
Alewife	1	0.9	0.1	1853	95.2	185.3	2	613	11	1360	132	1.2	91.0	5.2	82.6	42.8	0.2	70.1	0.6	96.2	16.5
Cisco	3	2.8	0.3	1	0.1	0.1	1					0.6					0.1	-	-	-	-
Round Whitefish				3	0.2	0.3	1			1	1	0.6			0.1	0.3	0.1	-	-	0.1	0.1
Gizzard Shad	1	0.9	0.1																		
White Bass	2	1.8	0.2																		
Coho Salmon				11	0.6	1.1															
Pearl Dace									8					3.8					-	-	-
Trout Perch									3	3	4			1.4	0.2	1.3			-	-	-
TOTAL	109	100	10.9	1944	100	194.4	171	674	211	1654	308	100	100	100	100	100	17.1	77.1	13.1	99.7	23.9

*CUE - based on a 24 h set of 8-50 ft panels ranging in size from 3.8 cm (1.5") to 12.7 cm (5.0")

spawning migration (Scott and Crossman 1973). The catch of alewife in spring 1978 was 70.1 fish/net set representing 91% of the total fish catch for that sampling period, while alewife catch in spring 1979 was 96.2 fish/net set representing 83% of the total catch. Alewife catch was considerably lower in spring 1982 (16.5 fish/net set) and also accounted for a lesser percentage (43%) of the total catch. Juvenile alewife, collected in 2.5 cm (1") mesh are included in the calculation of per cent composition for 1979, but are presented separately in terms of catch per unit effort (Table XI). They were the most abundant species caught in 2.5 cm mesh during spring 1979 sampling (54.9 fish/panel) but were absent during spring 1982 and barely represented (0.4 fish/panel) during fall 1978 sampling. The fluctuation in alewife CUE is probably related to their migratory, schooling behaviour rather than to an effect related to the disposal of excavated material.

The incidence of smelt in the dump site area also fluctuated. Smelt collected in 2.5 cm mesh were at their greatest density during the pre-dump spring 1979 survey (27.9 fish/panel) and to a lesser extent during the post-dump spring 1982 survey (14.1 fish/panel). In previous sampling periods, the smelt catch was quite low, remaining below 5 fish/panel (2.5 cm) or net set.

Burbot were present during all survey periods, with the maximum catch of 5.5 fish per net set occurring during spring 1982. This is considerably higher than the catch during any of the pre-dumping sampling periods, where the greatest catch occurred in spring 1978 (1.7 fish/net set). Longnose suckers were also more abundant in the spring post-dump survey (1.4 fish/panel) than in 1978 and 1979 spring pre-dump surveys (0.2 and 0.1 fish/panel, respectively). However these population fluctuations are probably primarily attributable to natural variation rather than a dumping effect.

In the fall, species composition and abundance differed considerably from that observed during the spring. Alewife and smelt were present in very low numbers, presumably having moved to deeper waters. Yellow perch, longnose sucker and lake chub were most abundant during fall pre-dump surveys (1977 and 1978). Catches of yellow perch ranged from 5 to 10 fish/net set, while longnose sucker and lake chub catches averaged 3 and less than 2.5 fish/net set, respectively. No fall post-dump surveys were conducted, therefore a comparison of pre-and post-dump fall results is not possible.

Fish species composition was similar at the control and dump site locations during the fall 1977 survey with some variation occurring in abundance of major species. During fall 1977,

TABLE XI

CATCH PER UNIT EFFORT OF 2.5 cm (1") GILL NET MESH
BRUCE 'B' DUMP SITE, 1978-1982

Species	1978 Fall	1979 Spring	1982 Spring
Smelt	4.5	27.9	14.1
Alewife	0.4	54.9	-
Lake Chub	0.2	0.1	-
Trout Perch	0.3	0.3	0.5
Longnose Sucker	0.3	-	-
Yellow Perch	0.3	-	-
Pearl Dace	0.7	-	-
White Sucker	0.1	-	-
TOTAL	6.7	83.2	14.6

longnose sucker (53%) was the most abundant species at the control location, followed by smelt (22%) and yellow perch (11%). At the dump site location yellow perch (59%) was the most abundant species, followed by longnose sucker (18%), burbot (7%) and smelt (5%). Total catch per unit effort was slightly higher at the dump site (17.1 fish/unit effort) than at the control location (10.9 fish/unit effort).

In spring 1978 surveys, alewife was the dominant species at both the control and dump site locations (95% and 91%, respectively). Smelt were also present at both locations, representing 4.0% of the control catch and 6.4% of the dump site catch. Total catch per unit effort was considerably higher at the control location (194.4 fish/unit effort) than at the dump site (77 fish/unit effort) reflecting mainly the greater abundance of alewife at the control location.

Coho salmon and round whitefish were also captured at the control location. Coho catch per unit effort was 1.1 fish/net set. The presence of coho salmon at the control location may have been in response to the large number of forage fish (alewife and smelt) in the area. Lake trout were not collected at any location during the dump site study.

Overall, fish catch at the dump site during spring surveys consisted mainly of the pelagic spring spawning species alewife and smelt during inshore migration. Burbot were three to five times more abundant in the post-dumping sampling period than in any of the pre-dumping sampling periods.

Yellow perch and longnose sucker were the two most abundant species collected during both fall sampling periods.

4.0 CONCLUSIONS

1. Pre- and post-dump survey water quality results were similar. For those parameters where changes occurred (ie, pH, turbidity) the differences were within the realm of seasonal and yearly fluctuations as observed during similar studies. Nutrient levels (nitrogen and phosphorus concentrations) were generally low, reflecting an oligotrophic water body.

   The disposal of the excavated material at the approved dump site did not appear to have an effect on water quality at the biological sampling site. Currents and dilution effects probably minimized any effect on water quality at the disposal site.

2. Fine substrate at the dump site consisted of a heterogeneous mixture of particles ranging in size from silt, sand and

clay (0.002 to 0.25 mm) to gravel (2 to 6 mm). At the three locations where pre- and post-dumping fine substrate data were collected, results were inconclusive due to the variation in substrate composition in all surveys. The organic content of the fine sediment was higher in the post-dump survey but less than that observed in the sediment tubes and was probably due to natural variation.

Diver surveys of two locations at the dump site revealed that sharp angled rock fragments indicative of recent deposition were present at one location. Analysis of photographs indicates that a heterogeneous mixture of particle sizes was present at both locations.

3. Echo sounding and side scan sonar surveys of the lake bottom did not identify the location of the dumped material.

4. Sedimentation rates observed at the dump site in 1982 are similar to sedimentation rates observed in 1978 and 1979. Mean daily sedimentation was less than 0.13 g/d beyond the 18 m depth contour with only one exception. Organic content was relatively low (<15% organic content) in samples obtained during pre- and post-dumping phases.

   No effect on sedimentation rate or organic content of the dump site sampling area could be related to the disposal of excavation material at the approved disposal location.

5. No changes in the zoobenthic community could be inferred from comparison of pre- and post-dumping sampling periods. Overall density of organisms was low both prior to dumping (X = 228.3 organisms/m^2) and after dumping (X = 177.8 organisms/m^2) and was similar to densities recorded during other studies. Oligochaeta and Diptera taxa were the most abundant during both phases.

6. A total of 308 fish were collected in gill nets at the dump site in spring 1982. Species composition was similar to other spring sampling periods, with alewife and smelt being the two most abundant species, followed by burbot and longnose sucker. The overall level of abundance (CUE) in 1982, however, was slightly lower for alewife and smelt and higher for burbot than in previous spring sampling periods. Fall sampling periods exhibited their own species composition characteristics and hence were not directly comparable with the spring 1982 post-dumping fishing results. No effect on the dump site fish community could be attributed to the disposal of material at the approved disposal site.

5.0 RECOMMENDATIONS

1. Further lake bottom investigations for the purposes of this study are not warranted.

2. In planning similar studies the rationale and study objectives must be resolved prior to survey commencement.

3. Sampling design should include two locations, dump site and suitable control, throughout the pre-dump and post-dump periods.

4. The inclusion of a survey during the dumping phase would provide valuable data for determining dumping related effects.

5. Sampling methods must be appropriate to meet the study objectives.

6. Sampling locations must be located in appropriate areas, checked for accurate placement, and identified by a Loran C or similar location fix.

7. Currents should be monitored in the vicinity of the disposal site during the dumping phase.

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APPENDIX 1

SUBSTRATE PER CENT COMPOSITION FROM SLIDE ANALYSIS SEPTEMBER, 1982

Location	Rep	Boulder	Cobble	Pebble	Gravel	Sand, Silt and Clay
31	1		41	10		49
	2		48	24		28
	3		32	36		32
	4	27	32	41		23
	5		23	30		47
	6		45	16		39
	7	41	33	2		24
	8		45	20		35
	9		48	29		23
	10		27	13		60
	11		41	29		30
	12		45	30		25
	13		27	21		52
	14		53	20		27
	15	12	21	31		36
	16		25	20		55
	17		18	9		73
	18		53	10		37
	19		58	18		24
33	1		58	23	1	18
	2		35	49	1	15
	3		38	26		36
	4		52	21		27
	5		36	47	2	15
	6	12	44	20		24
	7	85		3		12
	8	73	3			24
	9	42	33	17		8
	10	96	2			2
	11	91	7			2
	12	44	18	14		24
	13	1	55	23		21
	14	100				

APPENDIX 2

BRUCE 'B' DUMP SITE ZOOBENTHOS RESULTS
MAY 13, 1982

Species	Location and Sample Number						TOTAL
	10		18		37		
	#1	#2	#1	#2	#1	#2	
Amphipoda							
Pontoporeia affinis	2						2
Isopoda							
Asellus sp				1	1		2
Diptera							
Heterotrissocladius changi	2						2
Parakiefferiella sp						1	1
Oligochaeta							
Lumbriculidae	7	1				5	13
Tubificidae	3						3
Limnodrilus hoffmeisteri			1				1
TOTAL	14	1	1	1	1	6	24

APPENDIX 3

ZOOBENTHOS COLLECTION BEFORE AND AFTER DUMPING

Species	Before Dumping - 1977-1979								After Dumping - 1982			
	1977	1978		1979	Total No of Org (n=22)	% Comp	Mean # Per Sample	#/m^2	No of Org (n=6)	% Comp	Mean # Per Sample	#/m^2
	Fall	Spring	Fall	Spring								
Amphipoda												
Gammarus sp												
Pontoporeia affinis	1	4	18		23	20.4	1.0	46.5	2	8.3	0.3	14.8
Isopoda												
Asellus sp									2	8.3	0.3	14.8
Diptera												
Chironomini												
Chironomus sp												
Microtendipes sp												
Parachironomus sp												
Paracladopelma sp												
Paracladopelma winnelli		3	2	5	10	8.8	0.5	20.2				
Paralauterborniella sp												
Paratendipes sp												
Strictochironomus sp												
Tanytarsini												
Tanytarsus spp			1		1	0.9	-	2.0				
Orthocladiinae												
Heterotrissocladius spp		3	2		5	4.4	0.2	10.1				
Heterotrissocladius changi			1		1	0.9	-	2.0	2	8.3	0.3	14.8
Heterotrissocladius hirtapex		4		3	7	6.2	0.3	14.1				
Heterotrissocladius oliveri		4	11		15	13.3	0.7	30.3				
Hydrobaenus sp												
Parakiefferiella sp									1	4.2	0.2	7.4
Procladius sp		2			2	1.8	0.1	4.0				
Monodiamesa sp		1	1		2	1.8	0.1	4.0				
Potthastia sp		1		2	3	2.6	0.1	6.1				
Mollusca												
Sphaeriidae	1				1	0.9	-	2.0				
Pisidium spp		2	2	2	6	5.3	0.3	12.1				
Oligochaeta												
Lumbriculidae	6	1			7	6.2	0.3	14.1	13	54.2	2.2	96.3
Tubificidae	4	5		18	27	23.9	1.2	54.5	3	12.5	0.5	22.2
Limnodrilus hoffmeisteri				3	3	2.6	0.1	6.1	1	4.2	0.2	7.4
TOTALS	12	30	38	33	113			228.3	24	100		177.8

APPENDIX 4

ZOOBENTHIC COLLECTION AT DUMP SITE AND CONTROL DURING FALL 1977 AND SPRING 1978

Species	Control (n=10)				Dump Site (n=13)			
	No of Org	% Comp	Mean # Per Sample	#/m^2	No of Org	% Comp	Mean # Per Sample	#/m^2
Amphipoda								
Gammarus sp	1	0.4	0.1	4.4				
Pontoporeia affinis	11	4.3	1.2	48.9	5	11.9	0.4	17.1
Isopoda								
Asellus sp								
Diptera								
Chironomini	2	0.8	0.2	8.9				
Chironomus sp	1	0.4	0.1	4.4				
Microtendipes sp	1	0.4	0.1	4.4				
Parachironomus sp	1	0.4	0.1	4.4				
Paracladopelma sp	2	0.8	0.2	8.0				
Paracladopelma winnelli	9	3.6	0.9	40.0	3	7.1	0.2	10.3
Paralauterborniella sp	3	1.2	0.3	13.3				
Paratendipes sp	1	0.4	0.1	4.4				
Strictochironomus sp	2	0.8	0.2	8.9				
Tanytarsini	3	1.2	0.3	13.3				
Tanytarsus spp	5	2.0	.5	22.2				
Orthocladiinae	5	2.0	0.5	22.2				
Heterotrissocladius spp	29	11.4	2.9	128.9	3	7.1	0.2	10.3
Heterotrissocladius changi								
Heterotrissocladius hirtapex	64	25.3	6.4	284.4	4	9.5	0.3	13.7
Heterotrissocladius oliveri	1		0.1	4.4	4	9.5	0.3	13.7
Hydrobaenus sp	1		0.1	4.4				
Parakiefferiella sp	14	5.5	1.4	62.2	2	4.8	0.2	6.8
Procladius sp	7	2.8	0.7	31.1	1	2.4	0.1	3.4
Monodiamesa sp	5	2.0	0.5	22.2	1	2.4	0.1	3.4
Potthastia sp								
Mollusca								
Sphaeriidae	1	0.4	0.1	4.4	1		0.1	3.4
Pisidium spp					2	4.8	0.2	6.8
Oligochaeta								
Lumbriculidae	60	23.7	6.0	266.7	7	16.7	0.5	23.9
Tubificidae	24	9.5	2.4	106.7	9	21.4	0.7	30.8
Limnodrilus hoffmeisteri								
TOTALS	253			1124.4	42			143.6

APPENDIX 5

GILL NET CATCHES AT BRUCE 'B' DUMP SITE
MAY 1982

Location/Species	Date Lifted	Outer Nets																			Inner Nets																	Totals
		Parallel to Shore									Perpendicular to Shore									Parallel to Shore									Perpendicular to Shore									
		1	1.5	2	2.5	3	3.5	4	4.5	5	1	1.5	2	2.5	3	3.5	4	4.5	5	1	1.5	2	2.5	3	3.5	4	4.5	5	1	1.5	2	2.5	3	3.5	4	4.5	5	
Northeast Corner																																							
Smelt	May 13	20				1		1		1		—					1		1						1		1		47				1		2		2	67
Burbot										2											2																	12
Longnose Sucker												1																											2
Alewife																																						3
Southwest Corner																																						
Smelt											19									21				2		3		1					2		2			40
Burbot			.						1																													11
Alewife			64										8																	19									91
Trout Perch			.								1																											1
Northeast Corner																																						
Smelt	May 14	1								2						3		2		4				1		1		2											5
Burbot										1				1		2		2																					12
Longnose Sucker																														28			2		1				8
Alewife						1									1																								28
Round Whitefish																2				2																			1
Yellow Perch																																							3
Trout Perch																																							2
Southwest Corner																																						
Smelt		1																																				1
Burbot								2		2		1		1							6		3		1		3								1				9
Longnose Sucker																													1										1
Alewife																																							10
Trout Perch																																							1
TOTALS		22	64			2		3	1	8	20	2	8	3		8		5		27	8		3	3	2	4	4	3	48	47		2	1	3	3	2	2	308

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